WEEKLY REPORT – SINDHUJA CHADUVULA

The primary purpose of this report is to run a series of traffic simulation with varying parameters and then to analyze the results, especially collision data.

Our simulation consists of various vehicle types(‘vType’) and traffic flows(‘flow’). These are parameters for SUMO simulations:
Two vehicle types are defined:
DEFAULT_VEHTYPE: A yellow vehicle with various characteristics.
EGO_VEHTYPE: A red vehicle with slightly different characteristics.
Four vehicle flows are defined which define the routes vehicles take within the simulation.

Flow_ID	Vehicle_Type	Begin Time(s)	End Time(s)	Starting Edge	Ending Edge	Vehicles Per Hour
f_0_default	DEFAULT_VEHTYPE	0.00	200.00	-E29	E31	600
f_1_default	DEFAULT_VEHTYPE	0.00	200.00	-E32	E30	600
f_0_ego	EGO_VEHTYPE	0.00	200.00	-E29	E31	600
F_1_edge	EGO_VEHTYPE	5.00	200.00	-E32	E30	600

The Flow Information Table describes traffic patterns in the simulation. Each row represents a unique vehicle flow, specifying the vehicle type, duration and frequency of the flow, and the starting and ending road segments for that flow.

SCENARIO 1 – Studying about the rate of collisions and collision patterns across the simulation when one attribute is changed at a time in a roundabout.

In this scenario, we study the collisions caused between the Default vehicle and the ego vehicle in a roundabout, where only one attribute in the simulation is changed at a time to check which parameters are causing the collision.

In an in-depth analysis of roundabout simulation crash scenarios, several parameters were examined for their role in different collision types, such as intersection, lane-switching and rear-end , incidents. Notably, the 'tau,' 'collisionMinGapFactor,' 'sigmaerror', ‘sigmagap’ and ‘lcooperative’ parameters emerged as crucial determinants affecting the nature and number of these incidents. Within the framework of the EIDM car-following model, these variables were instrumental in determining the results of different collision situations. This underlines the necessity of meticulously adjusting and refining these particular parameters to improve traffic safety and reduce various collision risks in simulated settings.

Outputs:

CollisionMinGapFactor:
The heat map shows that more number of collisions has been occurred between Default vehicle and ego vehicle when the attribute ‘collisionMinGapFactor’ has been changed from

its default value, adjusting this value can significantly impact the safety and behavior of vehicles within a simulation. A higher value indicates

- Increased proximity to preceding vehicle
- Risk-Taking Behavior
- Less time for reaction

Tau:

Change in the Tau attribute has caused significant collisions in the roundabout. **'Tau'** parameter in SUMO represents the vehicle's desired time headway, which is the time a driver wants to place between themselves and the vehicle in front, under normal driving conditions. A lower value shows

- Shorter reaction time at Lower Tau
- Increased Aggressiveness
- Flow Disruptions

SigmaGap:

Adjusting the sigmagap parameter also causes collisions. Sigma(or sigmagap as mentioned) parameter in SUMO defines the driver's "imperfection" or deviation from the optimal driving behavior determined by the car-following model.

- Increased unpredictability at higher Sigma
- Difficulty in Gap Acceptance
- Stabilized Driving with Decreased Sigma

SigmaError:

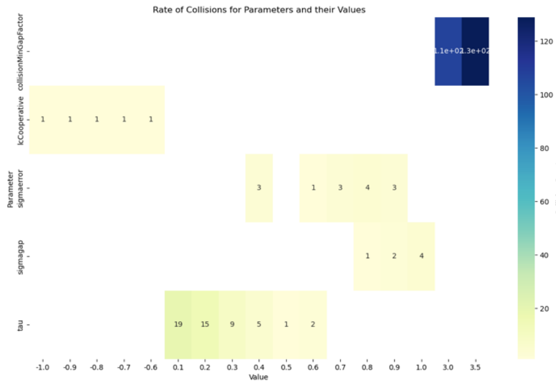
The sigmaerror parameter in SUMO pertains to the driver's "error" or variance in perception. Essentially, it quantifies how much a driver's perception of a situation might deviate from the actual reality.

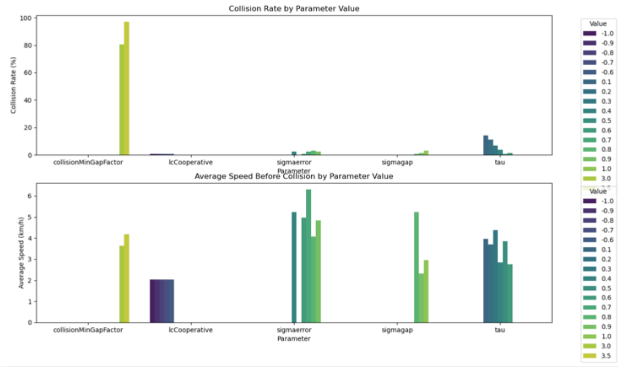
- Increased perception errors at Higher Sigmaerror
- Inconsistent Driving Behaviour
- Variablility in Gap Acceptance

Lccooperative:

He lccooperative parameter in SUMO governs the degree of cooperative behavior exhibited by drivers during lane changes. When drivers are more cooperative, they are more inclined to adjust their speeds to allow other vehicles to merge into their lane. Conversely, when they are less cooperative, they **might** maintain their speed or even accelerate, making it difficult for other vehicles to merge.

- Stable Collision Trend: Regardless of the varying levels of the lcCooperative parameter, the occurrence of only one collision each time indicates a certain level of stability or a consistent bottleneck point in the roundabout. This could be due to a specific traffic scenario that occurs irrespective of the cooperative behavior.





Collision Rate – The Collision Rate represents the frequency of collisions occurring within the simulation for a specific parameter value. It is calculated by taking the total number of collisions that occur during the simulation and normalizing it, usually per vehicle or per distance traveled.
A higher collision rate indicates that for the given parameter value, vehicles are more prone to collisions. Conversely, a lower collision rate suggests safer conditions under that parameter setting. From the bar graph, we can say that 'CollisionMinGapFactor' is causing more collisions, followed by 'Tau' and 'Sigmagap' being the least.

Average Speed- Average Speed refers to the mean speed of all vehicles within the simulation over a specified period or distance. It provides insight into the overall flow and efficiency of the traffic system under various parameter conditions.
A higher average speed typically indicates smoother traffic flow and potentially fewer congestion points or bottlenecks. In contrast, a lower average speed might suggest congestion, frequent stops, or more erratic driving behavior. However, it's worth noting that very high average speeds might also be associated with increased collision risks, especially if traffic behavior isn't smooth or if there are sharp turns, merges, or other complex traffic patterns.

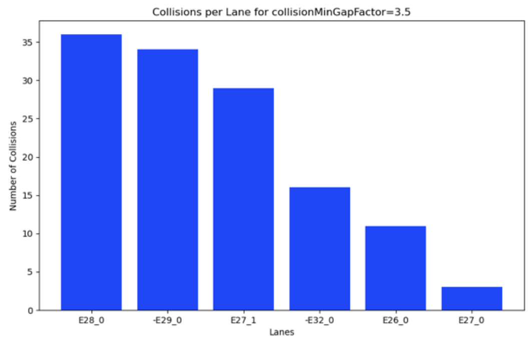
When analyzing the results from the simulation, it's crucial to consider both metrics together. While higher average speeds might seem desirable, they should not come at the expense of a higher collision rate. Similarly, while a lower collision rate is a primary goal, it shouldn't result in overly slow or inefficient traffic flow. The ideal scenario is to find parameter values that optimize both safety (lower collision rates) and efficiency (higher average speeds).

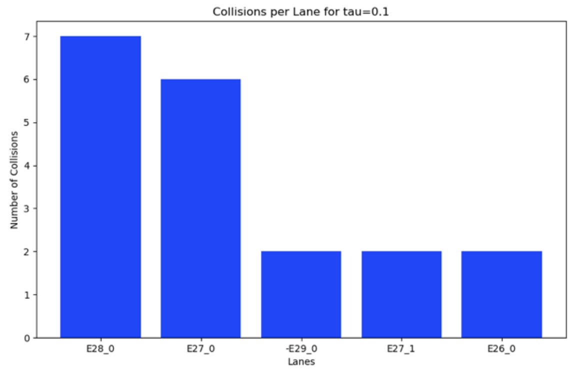
Collisions Location Analysis –

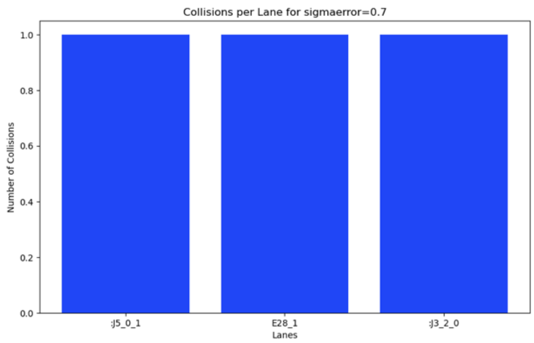
Analyzing the lanes or positions where collisions frequently occur can provide insights into potential problem areas in the simulation.

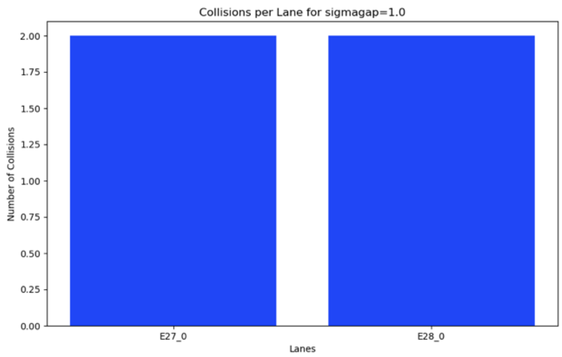
1. Entry point - These are locations where vehicles attempt to join the flow within the roundabout. Collisions here can result from drivers' inability to judge the speed and distance of oncoming vehicles. Improper signage or unclear road markings can exacerbate the issue.

2. Exit Points - Places where vehicles leave the roundabout and merge onto the connecting roads. Collisions at exit points can result from vehicles not signaling intentions, misunderstanding lane rules, or abrupt lane changes without adequate gap acceptance.
3. Central Island Overlaps - Portions of the roundabout where paths of vehicles in different lanes cross or overlap. Side-swipe or angle collisions are common in these sections, often caused by a lack of clear lane demarcations or misunderstanding lane usage rules.
4. Inner Lane- The innermost circulating lane of the roundabout. Higher speeds can reduce reaction times, and any unexpected braking can lead to rear-end collisions.
5. Outer Lane - The outermost circulating lane, usually closer to the entries and exits. This lane often witnesses merging and diverging actions, leading to potential side-swipe collisions or rear-end collisions due to speed differentials.



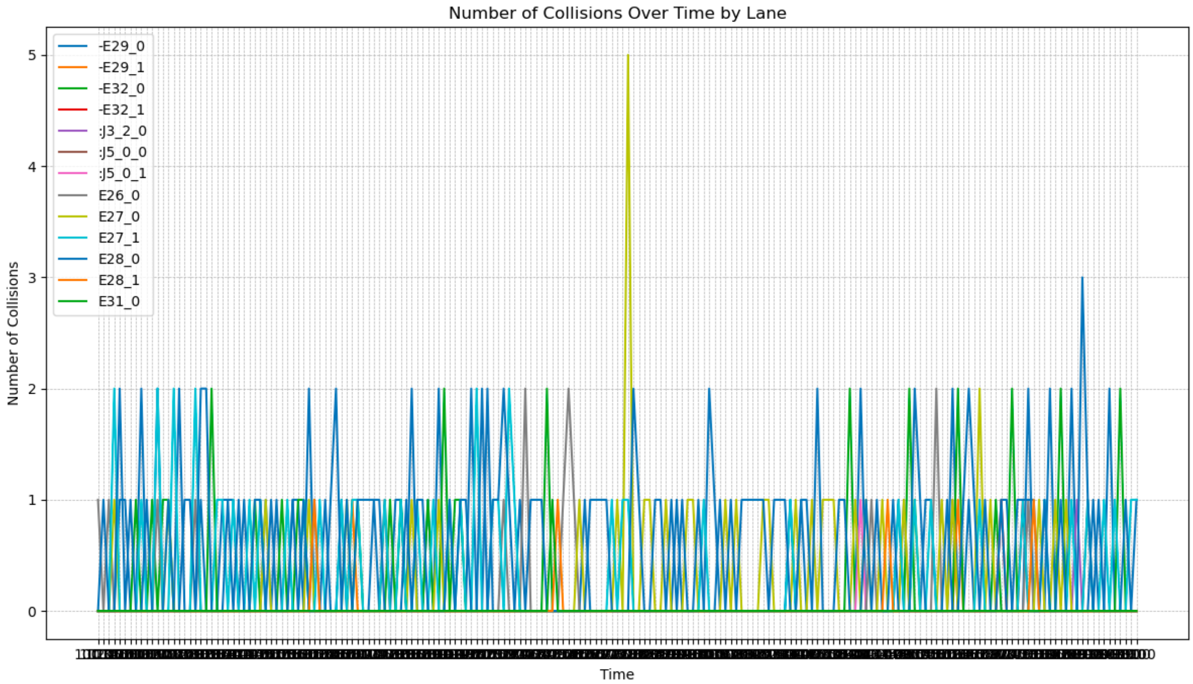






The analysis derived from the bar graphs prominently showcases that the E28_0 lane, being an outer lane of the roundabout, serves as a critical focal point for vehicular collisions. This lane has particularly exhibited heightened susceptibility to collisions when influenced by variations in parameters such as collisionMinGapFactor, sigmagap, and tau. Within the broader context of the entire simulation, E28_0 stands out as a distinct collision hotspot. The consistent pattern of accidents in this lane, driven by the interplay of these specific parameters, underscores the inherent vulnerabilities associated with outer roundabout lanes. It becomes imperative to pay specialized attention to such lanes and investigate the combined effect of the aforementioned parameters to ensure safer traffic dynamics.

Number of Collisions Over Time by Lane



Temporal Trends - The graph show if there are specific times when collisions are more frequent. For example, there might be spikes in collisions during rush hours or during certain weather conditions. From the plot we can say that collisions are more frequent in the lanes E27_1 and E28_0.

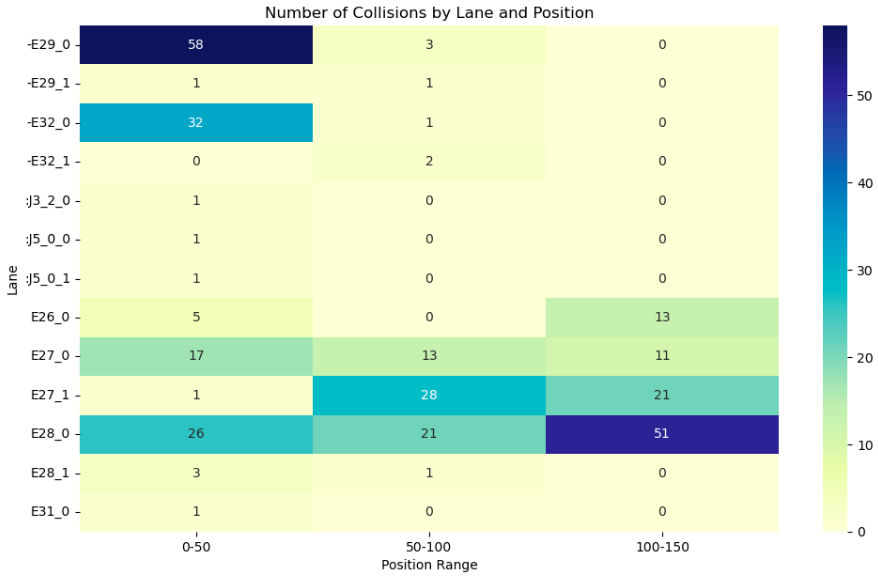
Lanewise Analysis - By comparing lanes, one could discern if certain lanes are more prone to accidents than others. For instance, here E28_0 lane consistently has more collisions over time than E28_1, it might suggest issues with merging or lane-changing behaviors.

Event Based Spikes - If there are sudden spikes in collisions for a particular lane at specific times, it could suggest external factors, like an incident causing a temporary obstruction or a change in traffic flow dynamics. We can clearly see a spike in lane E27_0 during a time interval of 273.00 seconds.

Number of Collisions by Lane and Position

Lane-wise Distribution: This would highlight which lanes are more prone to collisions. Some lanes, especially those where merging or exiting occurs, might have a higher number of collisions. For instance, the outermost lane might have more collisions if vehicles are frequently changing lanes or if there's merging traffic.

Position-Specific Hotspot: Within each lane, there might be specific positions or segments that are more collision-prone. For instance, positions near junctions, merges, or exits might see a higher collision rate due to the complexity of maneuvers in those areas. Similarly, areas where traffic must slow down or stop (like near pedestrian crossings or traffic signals) might also be high-risk zones.

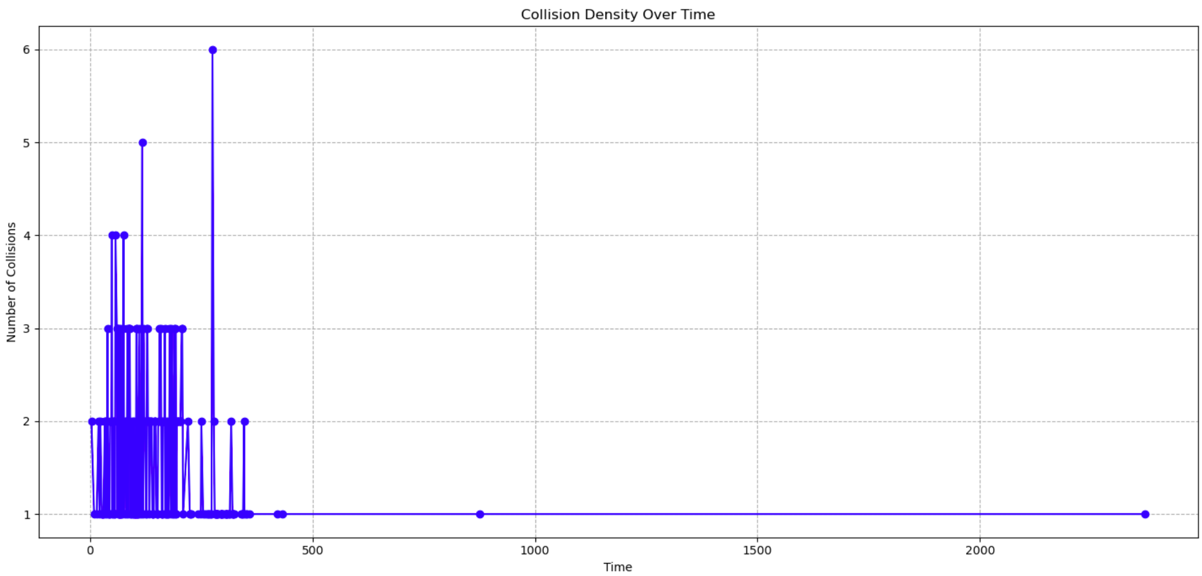


For the heatmap, we can say that lane -E29_0 at position 0-50 and lane E28_0 at position 100-150 is more prone to collision. As almost 50 collisions are taking place in this lane and position.

Collision Density Over Time

Collision Density - This is a measure of how frequently collisions occur in a given space during a specified timeframe. The term "density" indicates that we're not only looking at raw numbers (i.e., total collisions) but rather considering the rate or concentration of these incidents.

Temporal Span - This refers to the period over which the data is observed or analyzed. It could be as short as an hour, a day, or as long as a year or even a decade. The chosen time span allows for identifying patterns, anomalies, or trends in collision occurrences.

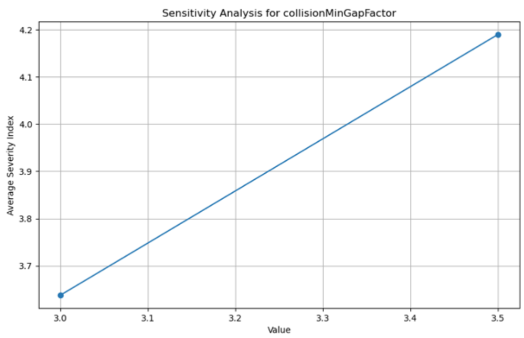


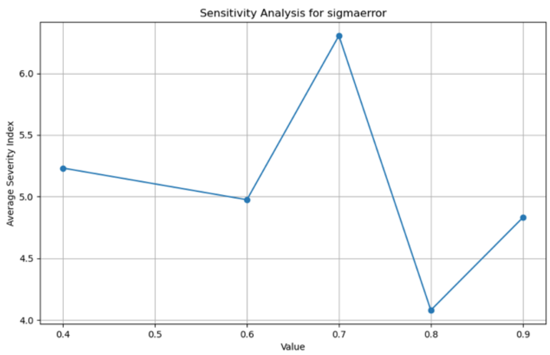
Sensitivity Analysis for each parameter :

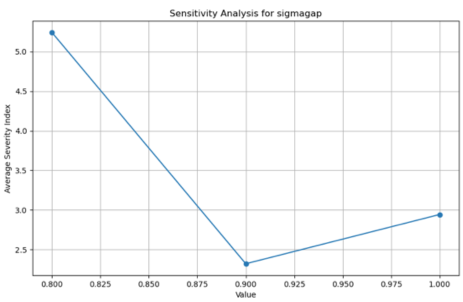
Collision Severity Index – Utilize the speed of the vehicles involved in the collision to estimate the severity.

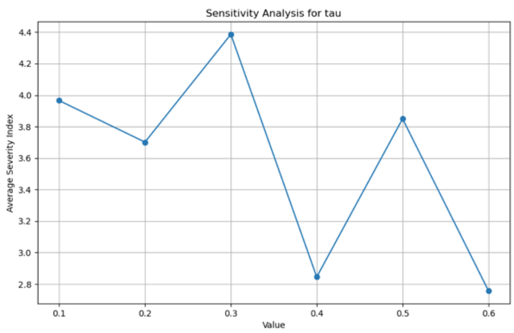
Tau - Higher tau values might result in collisions with a higher severity index, indicating more dangerous collisions, given that drivers take longer to respond.
CollisionMinGapFactor – higher collisionmingapfactor yields higher severity index.
Sigmagap - A lower sigmagap might lead to collisions with a higher severity index, suggesting riskier behavior when drivers aim to maintain shorter gaps.
Sigmaerror - A higher sigmaerror could correlate with a higher severity index, indicating that greater variability in driver behavior might lead to more severe collisions.

The inclusion of the severity index in the sensitivity analysis offers a deeper understanding of the impact of each parameter. Rather than just counting collisions, it weighs them based on their severity. This allows for a more nuanced understanding of how changes in driving behaviors and conditions, represented by the parameters, impact road safety.







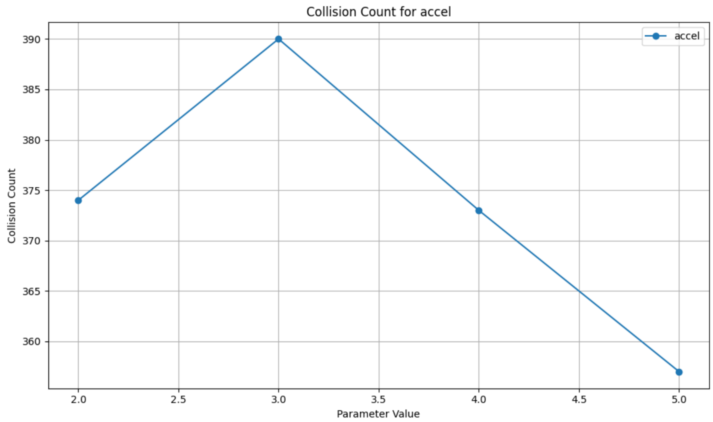


SCENARIO 2 – Studying the trends of how other paramerets will cause collisions, if collisionMinGapFactor, tau, sigmaerror, sigmagap and lccooperative are changed for the EGO and DEFAULT vehicle in a roundabout.

In this study we are going to plot line graphs for each parameter and its value and findout which parameter value is likely to cause more collisions

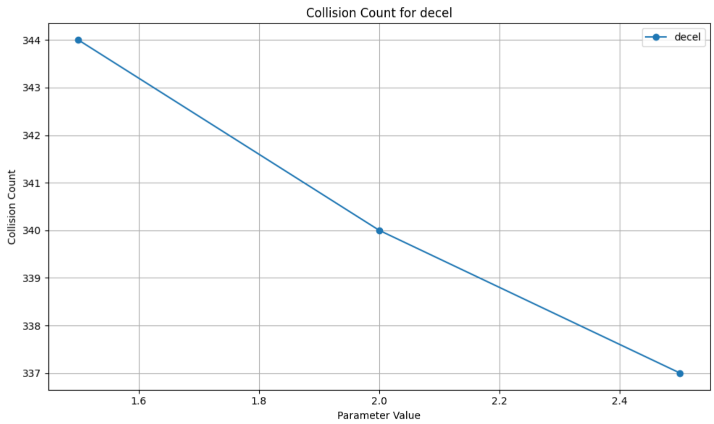
Acceleration:

Acceleration, the rate at which a vehicle changes its speed, plays a crucial role in shaping traffic dynamics, especially when interacting with other parameters like tau, collisionMinGapFactor, sigmaerror, sigmagap, and lcCooperative. Higher acceleration values, combined with prolonged reaction times (tau), reduced gap preferences (collisionMinGapFactor), and increased driver variability (sigmaerror), can lead to rapid and potentially unsafe vehicular responses, resulting in a heightened risk of collisions. This risk is further compounded when drivers desire shorter headways (sigmagap) or exhibit non-cooperative lane-changing behaviors (lcCooperative). As each parameter varies, the interplay results in diverse and often uneven trends in collision occurrences, underscoring the importance of a holistic understanding of these parameters in traffic safety analysis.



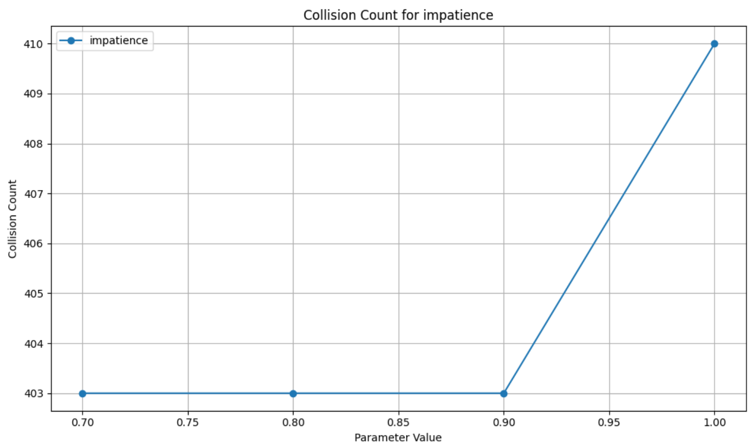
Deceleration:

Deceleration, indicative of how swiftly a vehicle slows down, becomes particularly consequential in the backdrop of specific parameter settings, such as a short reaction time (tau=0.1), a preference for smaller gaps leading to proximity (collisionMinGapFactor=3.5), heightened driver inconsistency (sigmaerror=0.8), a desire for minimal headways (sigmagap=1.0), and non-cooperative lane-changing tendencies (lcCooperative=-1). When vehicles decelerate sharply amidst these conditions, it can strain the already fragile equilibrium of the traffic flow, leading to a higher likelihood of collisions. This is because other vehicles may not have adequate time or space to adjust to rapid changes in speed, especially given the parameters that already predispose the system to potential conflicts. As deceleration values shift, it results in a discernible decreasing trend in collision instances, emphasizing the delicate balance between slowing down and the prevailing driving conditions.



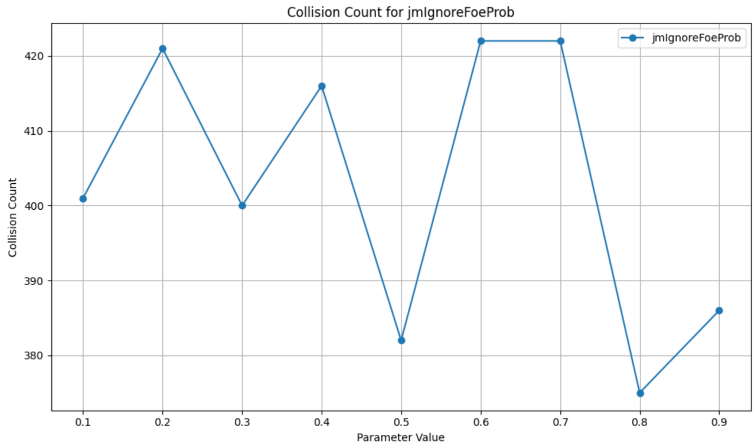
Impatience

Impatience, a measure of a driver's willingness to wait, can significantly influence collision dynamics, especially when compounded by specific parameter adjustments. Within the context of a minimal reaction time (tau=0.1), a propensity for tighter gaps (collisionMinGapFactor=3.5), increased driver variability (sigmaerror=0.8), a preference for reduced headways (sigmagap=1.0), and aggressive, non-cooperative lane-changing behaviors (lcCooperative=-1), the role of impatience becomes even more pronounced. Initially, as impatience values vary, the collision rate remains consistent, indicating a threshold or saturation point in driver behaviors. However, beyond this point, an increase in impatience corresponds to a spike in collisions. This suggests that there's a tipping point where rising impatience, combined with the aforementioned parameters, overwhelms the traffic system's ability to compensate, leading to more frequent conflicts and collisions.



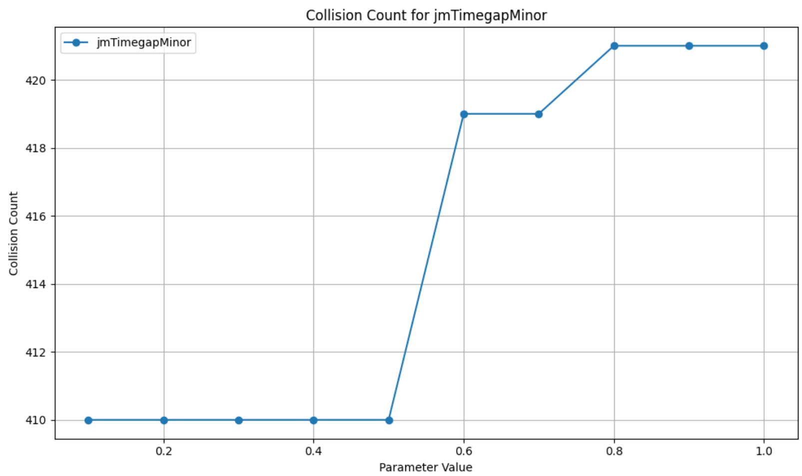
JmIgnoreFoeProb

The parameter "jmignorefoeprob" denotes the probability with which a vehicle disregards the presence of conflicting traffic (foes) at junctions. Alterations in this value, particularly when integrated with a set of parameters like minimal reaction time (tau=0.1), a proclivity for closer gaps (collisionMinGapFactor=3.5), heightened driver variability (sigmaerror=0.8), a bias for smaller headways (sigmagap=1.0), and aggressive non-cooperative lane-changing behaviors (lcCooperative=-1), can result in an erratic collision trend. As "jmignorefoeprob" increases, vehicles are more likely to overlook potential hazards at intersections, leading to elevated risks. However, the erratic trend suggests that certain values of "jmignorefoeprob", even when combined with the given parameters, might lead to counterintuitive outcomes where vehicles' interactions result in sporadic safety pockets or heightened danger zones, depending on the intricate interplay of these parameters in the simulated environment.



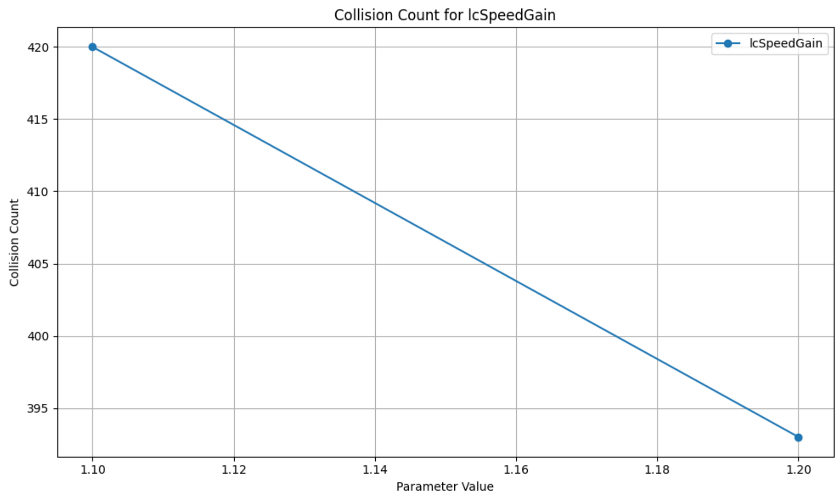
Jmtimegapminor

The "jmtimegapminor" parameter describes the accepted time gap to minor roads in a junction scenario. When manipulated alongside specific parameters such as minimal reaction time (tau=0.1), an inclination for tighter gaps (collisionMinGapFactor=3.5), increased driver variability (sigmaerror=0.8), a tendency for shorter headways (sigmagap=1.0), and aggressive non-cooperative lane-changing behavior (lcCooperative=-1), it can significantly influence collision trends. At initial values, "jmtimegapminor" may offer enough cushion, leading to a steady collision rate. However, as this gap shrinks, collisions could surge due to reduced safe thresholds. But beyond a certain critical value, the rate might stabilize, perhaps as drivers in the simulation adapt or as more aggressive maneuvers become less frequent due to resulting congestion, encapsulating the nuanced effects of intersecting parameters on vehicular interactions and safety outcomes.



LcSpeedGain

The parameter "lcspeedgain" reflects the motivation of a driver to change lanes based on potential speed benefits. When calibrated alongside aggressive settings such as minimal reaction time (tau=0.1), tighter collision gaps (collisionMinGapFactor=3.5), elevated driver unpredictability (sigmaerror=0.8), diminished safe distances (sigmagap=1.0), and hostile non-cooperative lane-changing behavior (lcCooperative=-1), its influence becomes quite pronounced. Initially, as the "lcspeedgain" value increases, drivers might be more eager to switch lanes for marginal speed advantages. However, the observed decreasing trend in collisions as "lcspeedgain" ascends could be counterintuitive; it might be due to drivers becoming overly cautious or restrained in such aggressive simulation settings, recognizing the risks associated with frequent lane changes, ultimately leading to fewer collision instances as the drive for speed gain intensifies.



- Other Attributes like lcpushy, lcstrategic, maxspeed, eidmaccfactor, eidmdelta, eidmmingap, eidmtau remained constant, i.e even with different values the number of collisions caused by these parameters remained same